# MEDICAL APPLICATIONS OF NASA-DEVELOPED SCIENCE AND TECHNOLOGY

QUARTERLY PROGRESS REPORT NO. 4
1 January - 31 March 1967

NASA Contract No. NASr-63(11)
MRI Project No. 2961-E

For

NASA Technology Utilization Division
Office of Technology Utilization
Code UT
National Aeronautics and Space Administration
Washington, D. C. 20546

MRI
MIDWEST RESEARCH INSTITUTE
425 VOLKER BOULEVARD/KANSAS CITY, MISSOURI 64110/AC 816 LO 1-0202

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by

David Bendersky

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## PREFACE

This report covers the project activities on NASA Contract No. NASr-63(11) during the months of January, February and March 1967, and also contains a summary of the activities during the period from 1 April 1966 to 1 April 1967.

The program is under the technical supervision and management of Paul C. Constant, Jr., Manager, Technology Utilization, Engineering Division. David Bendersky, Director, MRI Biomedical Applications Team, prepared this report. Members of the MRI Biomedical Applications Team who contributed to the activities reported herein included E. K. Bauman, David Bendersky, Paul C. Constant, Jr., Wilbur E. Goll, Dr. William G. Kubicek, Harry Ludwig, Mathew L. Petrovick, Dr. James B. Reswick, Dr. Alfred W. Richardson, Robert W. Schafer, and Dr. James W. Trank.

The Case Institute of Technology, the University of Kansas Medical Center, the University of Minnesota Medical School, Northwestern University, Saint Louis University School of Medicine, and the University of Wisconsin Medical Center are cooperating in the project.

Approved for:

MIDWEST RESEARCH INSTITUTE

Harold L. Stout

Harold L. Stout, Director
Engineering Division

28 April 1967

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# I. INTRODUCTION

The objective of this project is to transfer NASA-developed science and technology to the nonaerospace medical field. NASA, in its concern with the function of man in an aerospace environment, has generated an extensive body of science and technology pertaining to medicine. In addition, the aerospace program has led to a host of technical innovations which may be applicable to the solution of medical problems. The NASA Technology Utilization Division is sponsoring this project to assist in making these aerospace developments available to the nonaerospace medical community.

The procedure being used to transfer aerospace technology into medical applications consists of the following basic steps: (1) medical problems are obtained from the cooperating medical schools, (2) aerospace technology is searched to identify potential solutions to the medical problems, (3) the potential solutions are evaluated, and (4) information on successful medical applications of aerospace technology is disseminated for general use by the medical profession.

# II. FOURTH QUARTER PROGRESS

This section is a report of the project activities during the months of January, February and March 1967.

## A. Medical Problem Activities

### Electrocardiographic Electrodes, Medical Problem No. KU-1*

The NASA spray-on electrodes were used on 567 school children by Dr. R. Lauer's staff at the University of Kansas Medical Center to obtain electrocardiograms under exercise conditions during this report period. Some of these electrodes were applied by simply brushing the conductive mixture onto the skin with a small paint brush. Satisfactory results were obtained with these brushed-on electrodes.

The Hauser Research and Engineering Company, Boulder, Colorado, has initiated the production of a commercial version of the spray-on electrodes,

* The problem number code designates the originating school (KU = Kansas University, SLU = St. Louis University, etc.).

shown in Fig. 1. The conductive mixture is contained in a pressurized can which is equipped with a plastic nozzle to direct the spray. One of these units was obtained and given to Dr. R. Lauer, the University of Kansas Medical Center, for evaluation.

A motion picture* showing how the original NASA spray-on electrode technology is being applied at the University of Kansas Medical Center was prepared and sent to the NASA Technology Utilization Division, Washington, D.C.

Information concerning the spray-on electrodes was requested by and sent to Western Electric Company, Lee's Summit, Missouri; New York University College of Dentistry, New York, New York; Human Resources Research Office, Fort Benning, Georgia; Women's Medical College of Pennsylvania, Philadelphia, Pennsylvania; University of Oregon Medical School, Portland, Oregon; Spray-on Products, Inc., Bedford Heights, Ohio; Sterodyne, Inc., Troy, Michigan; Brunswick Corporation, St. Louis, Missouri; Electrodyne Company, Westwood, Massachusetts; and Southern Illinois University, Carbondale, Illinois.

Respiration Measurement, Medical Problem No. KU-2

A quadrupole mass spectrometer is being developed by Dr. Kubicek and his co-workers at the University of Minnesota under a NASA contract, supported by the Manned Spacecraft Center, for the continuous monitoring of spacecraft cabin atmosphere. This instrument is a potential solution to Medical Problem No. KU-2, the rapid measurement of oxygen consumption and carbon dioxide generation during respiration. Arrangements have been made to evaluate this instrument at the University of Kansas Medical Center as soon as a unit is available. Dr. Kubicek has indicated that it will probably be several months before a unit is available because of purchased parts shortages and contractual matters.

A respiration analyzer was developed by the North American Aviation Corporation for the NASA Flight Research Center. This analyzer is described in North American Aviation report titled "The Design, Fabrication and Feasibility Testing of a Prototype Airborne Respiration Analyzer," NASA Contract NASr-966, March 1966. It appears that this equipment, with some modification, may be applicable to Medical Problem No. KU-2, but would require considerable operating attention. Information received from the Flight Research Center indicated that only one prototype has been constructed and is still being tested, so that no unit is presently available for evaluation on Medical Problem No. KU-2.

* This film also covers the respirometer helmet (KU-5) and the muscle accelerometer (SLU-7).


Fig. 1 - Commercial Model of the Spray-on Electrodes

The Perkin-Elmer Corporation developed an oxygen sensor for the NASA Manned Spacecraft Center, which is described in their Engineering Report No. 8268, entitled, "Final Report, Prototype Oxygen Sensor," NASA Contract No. NAS9-3355, 20 January 1966. A study of this report indicated that the sensor might be applicable to Medical Problem No. KU-2. Mr. John Lem, NASA Manned Spacecraft Center, was contacted. Mr. Lem reported that although the basic sensor is available, a considerable amount of necessary accessory equipment is not available. Furthermore, the unit was found to be unstable. Therefore, it was decided not to attempt any further evaluation of this unit at this time.

Respirometer Helmet, Medical Problem No. KU-5

The application of the respirometer helmet was continued at the University of Kansas Medical Center. Respiration data were collected on 136 high school students with the helmet during this report period, with no reported difficulties. Figure 2 shows the helmet being used to determine oxygen consumption under exercise.

A motion picture showing the application of NASA technology to the development of the respirometer helmet was prepared and sent to the NASA Technology Utilization Division, Washington, D. C.

Information on the respirometer helmet was requested by and given to Northwestern University Medical School, Chicago, Illinois, and the Western Electric Company, Lee's Summit, Missouri. Both of these organizations plan to construct and use this helmet in respiration research.

Nasal Pack, Medical Problem No. KU-15

The experimental cellulose sponge nasal pack was evaluated by Dr. F. Kerchner, at the University of Kansas Medical Center. This nasal pack does not appear to be satisfactory because of inadequate mechanical strength, blood absorption and removal problems.

Brain Lesion Device, Medical Problem No. KU-17

The specifications for the dielectric material to be used in the experimental brain lesion probe were established. Representatives of Gutlon Industries, Metuchen, New Jersey, were contacted to obtain the required dielectric material. Arrangements were made for them to determine whether their high "k" ceramic materials would be satisfactory for this application. Further development is awaiting the results of this determination.

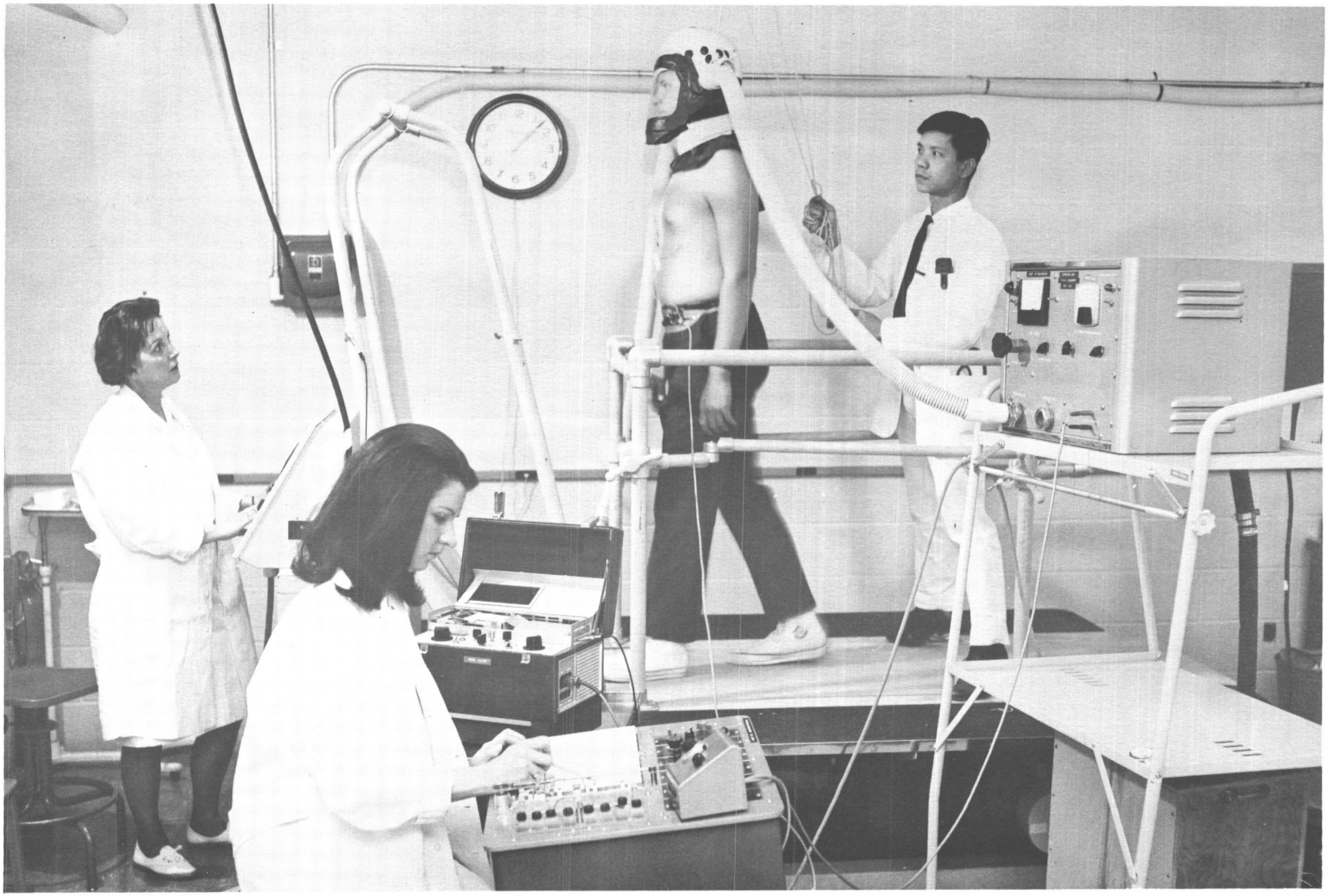

Fig. 2 - Oxygen Consumption Tests being conducted at the University of Kansas Medical Center using the Respirometer Helmet

## Support for Eardrum Rupture, Medical Problem No. KU-23

A Medical Problem Abstract on Problem No. KU-23, concerning a support to assist the healing of ruptured eardrums, was prepared, approved by NASA-TUD, and submitted for distribution to the NASA centers. A copy of this abstract is contained in Appendix I.

## Cardiac Output Measurement, Medical Problem No. KU-24

An additional medical problem was received from the University of Kansas Medical Center during this report period. This problem concerns the need for a method to measure cardiac output without inserting anything into the body.

Dr. Kubicek, University of Minnesota, has developed a cardiac output measuring system, under partial NASA support, which appears to be applicable to Medical Problem No. KU-24. This system is described in the December 1966 issue of Aerospace Medicine in an article titled "Development and Evaluation of an Impedance Cardiac Output System," by Kubicek, et al. Preliminary arrangements have been made to evaluate this system at the University of Kansas Medical Center in connection with Medical Problem No. KU-24, as soon as a test unit is available.

## Muscle Accelerometer, Medical Problem No. SLU-7

The muscle accelerometer was used at Saint Louis University School of Medicine on five neurological patients to collect muscle reflex data, with good results. A paper describing this work, prepared by Sister M. Agnita Claire Day, Professor of Nursing at Saint Louis University, is given in Appendix II. This paper was submitted to the Aerospace Medical Association for publication. This work will be summarized in a presentation by Sister Claire and Dr. L. Tureen at the 38th Annual Meeting of the Aerospace Medical Association, Washington, D. C. on April 10, 1967.

A motion picture showing the application of NASA technology to the muscle accelerometer was prepared and sent to the NASA Technology Utilization Division, Washington, D. C.

## Sterile Hospital Room Atmosphere, Medical Problem No. UM-1

The literature search on clean-room technology revealed a considerable number of reports on this subject. Copies of these reports have been obtained and forwarded to Dr. Kubicek, University of Minnesota Medical School. Dr. Kubicek has reported that the engineering design and construction details to build a germ-free operating suite and adjacent recovery room is amply

supplied in these reports. The information is expected to save thousands of dollars of time and effort when the Department of Surgery at the University undertakes the construction of these sterile rooms.

Speech Spectrum Analysis, Medical Problem UM-4

The literature search conducted on speech spectrum analyses revealed a considerable number of reports on this subject. Copies of these reports have been obtained and sent to Dr. Kubicek, University of Minnesota Medical School. Dr. Kubicek has reported that although no applicable NASA equipment was found, the information obtained through these reports has been used to formulate plans to obtain a special commercial spectrum analyser for use in several studies at the University. These studies include speech spectrum analyses and subsequent synthesis, frequency analysis of electromyographic potentials recorded from both normal individuals and patients with neuromuscular disorders, and research on cardiac and circulatory dynamics.

Measurement of Temporomandibular Joint Action, Medical Problem No. NU-1

An unsuccessful attempt was made to obtain one of the triaxis accelerometers developed by the Electro-Optical Company for the NASA Ames Research Center. These accelerometers are of interest as a potential solution to Medical Problem No. NU-1. Unfortunately, none of these accelerometers are presently available for evaluation on this problem.

As a secondary choice, the miniature piezo electric accelerometer, described in NASA Tech Brief 66-10534, copy in Appendix III, may be applicable to Medical Problem No. NU-1. Arrangements were made for one of these accelerometers to be sent from Ames Research Center to Northwestern University Medical School for evaluation in connection with this medical problem.

Telemetry System for Football Players, Medical Problem No. NU-2

NASA has developed a helmet and telemetry system for obtaining EEG's on pilots and astronauts, described in NASA Tech Briefs 66-10536 and 65-10203, copies given in Appendix III. Information on these items was obtained and sent to M. L. Petrovick, Northwestern University Medical School, for evaluation in connection with Medical Problem No. NU-2. A preliminary evaluation of the miniature amplifier described in Tech Brief 65-10203 was made at Northwestern University. The preliminary evaluation indicates that this item may be applicable to Medical Problem No. NU-2 and further evaluation is planned.

The helmet with built-in EEG electrodes described in Tech Brief 66-10536 was evaluated at Northwestern University. It was found that these electrodes would not tolerate the heavy impacts which are encountered in a football helmet.

An abstract of Medical Problem No. NU-2 was prepared and sent to NASA-TU Headquarters for distribution. A copy is in Appendix I.

Liquid Delivery to the Respiratory Tract, Medical Problem No. UW-1; Eyelid Closure Recording, Medical Problem No. UW-2; and Auditory Stimuli, Medical Problem No. UW-3

Literature searches were made on Medical Problems Nos. UW-1, UW-2, and UW-3 at ARAC. The results of these literature searches were sent to Harry Ludwig at the University of Wisconsin Medical Center. Medical Problem Abstracts were prepared on each of these problems and sent to NASA-TU Headquarters for distribution. Copies are in Appendix I.

Miniature Motors and Batteries, Medical Problem No. CI-1; Rotational Position Devices, Medical Problem No. CI-2; Materials for Implanted Electronics, Medical Problem No. CI-3; Radio Frequency Telemetry Link, Medical Problem No. CI-4; and Micropower Circuitry, Medical Problem No. CI-5

Literature searches were conducted on Medical Problems Nos. CI-1, CI-2, CI-3, CI-4 and CI-5 at ARAC. The results of these literature searches were sent to Dr. James Reswick at Case Institute of Technology. Abstracts on Medical Problems Nos. CI-1 and CI-2 were prepared and sent to NASA-TU Headquarters for distribution. Copies are in Appendix I.

## B. Miscellaneous Activities

In addition to the print, an optical master of the technology transfer film on the respirometer helmet, the muscle accelerometer and the spray-on electrodes was prepared and sent to NASA-TU Headquarters.

The status of Medical Problems Nos. KU-2, KU-4, KU-9 and UM-3 was requested by and furnished to the Biomedical Applications Team at Southwest Research Institute, San Antonio, Texas.

Information on the Gemini ECK electrodes, Tech Brief 64-10025, and the electrode paste, Tech Brief 66-10049, were requested by and furnished to the Electrodyne Company, Westwood, Massachusetts.

Information on the helmet with built-in EEG electrodes, Tech Brief 66-10536, and the miniature amplifier, Tech Brief 65-10203, were furnished to Dr. W. Ko, Case Institute of Technology.

Information on biotelemetry, NASA Technology Utilization Report SP-5023 and Tech Brief 66-10057, was furnished to the Space Sciences Center, University of Missouri, Columbia, Missouri.

Information on the electrocardiographic radio, "Biotelemetry in Medicine," R. T. Allen, Bio/Medical Instrumentation, December 1964, was furnished to the Baxter Laboratories, Morton Grove, Illinois.

General information on the project was requested by and furnished to Baxter Laboratories, Morton Grove, Illinois; Brunswick Corporation, Saint Louis, Missouri; Hebrew University Medical School, Jerusalem, Israel; University of Missouri School of Medicine, Columbia, Missouri; National Institutes of Health, Bethesda, Maryland, and Frost, Inc., New York, New York.

A summary of the project activities to date for the VRA groups at the University of Wisconsin and Case Institute of Technology was prepared and submitted to the NASA-TU Headquarters.

A paper on the muscle accelerometer and spray electrode technology transfers was prepared and submitted to the International Conference on Medical and Biological Engineering, Stockholm, Sweden, 14 - 19 August 1967.

## III. ANNUAL SUMMARY

A total of 49 medical problems was pursued by the MRI Biomedical Applications Team during the period 1 April 1966 to 1 April 1967. Twenty of these problems were for the University of Kansas Medical Center, eleven problems for the Saint Louis University School of Medicine, eight problems for the University of Minnesota Medical School, two problems for Northwestern University Medical School, three problems for the University of Wisconsin Medical Center, and five problems for Case Institute of Technology. A list of these medical problems is given in Appendix IV.

Literature searches were made on 39 medical problems listed in Appendix IV. These were computerized literature searches made by ARAC and STIF. These searches revealed related aerospace technology on 29 of the medical problems. These potential solutions are now in various stages of evaluation.

Thirty-two Medical Problem Abstracts were prepared for distribution to the NASA center and other appropriate organizations. Thirty-five responses were received in connection with these abstracts and forwarded to the originating medical schools.

Four medical problems have been solved and three are expected to be solved shortly. These include a new technique for applying electrocardiogram electrodes (solution to Medical Problem No. KU-1), a respirometer helmet for determining oxygen consumption (solution to Medical Problem No. KU-5), a special accelerometer for measuring muscle reflexes and tremors (solution to Medical Problem No. SLU-7), a tri-axial accelerometer for measuring jaw bone motion (solution to Medical Problem No. NU-1), a mass spectrometer for rapid measurement of respiration gases (solution to Medical Problem No. KU-2), an external method for measuring blood flow (solution to Medical Problem No. KU-14), and techniques for providing sterile air for operation and post operation rooms (solution to Medical Problem No. UM-1). Further details of these solutions are given in Quarterly Progress Reports Nos. 1, 2, and 3.

Fifteen publications, technical presentations and news articles were prepared to disseminate information on the activities of the MRI Biomedical Applications Team. Inquiries on the project were received from approximately 50 doctors, hospitals, government agencies, and industries. Responses were sent to each inquirer.

## IV. FUTURE ACTIVITIES

The following activities are planned.

1. A presentation of the muscle accelerometer will be made at the Aerospace Medical Association Conference, Washington, D. C., 10 April 1967.

2. The commercial version of the spray-on electrodes will be evaluated at the University of Kansas Medical Center.

3. The mass spectrometer developed at the University of Minnesota will be evaluated at the University of Kansas Medical Center in connection with Medical Problem No. KU-2.

4. The application of the respirometer helmet will be continued at the University of Kansas Medical Center.

5. The investigation of the brain lesion device will be continued in connection with Medical Problem No. KU-17.

6. The cardiac output system developed at the University of Minnesota will be evaluated at the University of Kansas Medical Center in connection with Medical Problem No. KU-24.

7. The application of the muscle accelerometer to Medical Problem No. SLU-7 will be continued at the Saint Louis University School of Medicine.

8. The NASA Ames Research Center tri-axial accelerometer will be evaluated at Northwestern University Medical School in connection with Medical Problems Nos. NU-1 and NU-2.

9. Additional medical problems will be obtained from the cooperating schools and processed.

# APPENDIX I

## MEDICAL PROBLEM ABSTRACTS

# MEDICAL PROBLEM

January 1967

This problem abstract is designed to call to the attention of NASA personnel (and others who have agreed to participate) significant barriers that impede the progress of biomedical research and health care. The purpose is to bring to bear on these problems the expertise that resides in NASA. If you feel you can make a contribution, please communicate your suggestions to the Technology Utilization Officer at your installation. Also, alert him to any suggestions which can constitute inventions so that patent applications may be made. Thank you.

No. KU-23

## Support to Assist Healing of Eardrum Rupture

What is Needed: A biologically inert film material which may be used to provide a superstructure for the growth of new tissue to bridge an eardrum rupture. The material should be insoluble or sparingly soluble in body fluids, but should be soluble in a fluid which is biologically innocuous. The material should be able to withstand sterilization by one of the standard techniques: steam or gas sterilization.

Background: The eardrum may be perforated by either trauma or infection. If the perforation diameter is greater than 3 mm. it will not heal spontaneously and hearing will be permanently impaired.

A bridging surface, a piece of "film," placed over the perforation will provide support for the tissue growth needed to bridge the aperature. At the present time materials such as cigarette paper are used but these have the disadvantage that they are difficult to remove, usually an anesthetic is required and there is risk that the new membrane will be damaged.

If a material were available which could be removed by simply dissolving it away from the new eardrum membrane, the need for anesthesia and the risk of membrane damage would be greatly reduced.

Source of Problem: Dr. Kirchner, Department of Otorhinolaryngology, Kansas University Medical Center, Kansas City, Kansas.

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December 1966

No. UW-1

## Delivery of Water and Medication to the Respiratory Tract

What is Needed: A head gear or face mask admitting a special atmosphere containing medication to the nose and mouth. Requirements include suitable valving or venting to preclude rebreathing, reducing condensation, comfort, convenience, low cost, effective mist generation, and adaptability to different head sizes.

Background: Deposition of water and water soluble compounds is a relatively common approach to treating infections of the airways. Such infections occur in both normal and retarded children and are a particular problem in children with cystic fibrosis. The current method requires placing the individual in a tent containing air-borne droplets generated in one way or another. This system requires placing the entire patient in this bulky structure; the only parts which need be exposed to the special atmosphere, however, are the nose and mouth.

Authority: Dr. Arthur A. Siebens, M.D., Director, Rehabilitation Center, University of Wisconsin.

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No. UW-2

## Eyelid Closure Recording

What is Needed: A means for detecting the time course and amplitude of eyelid closing.

Background: The eyeblink response has been used extensively to study classical conditioning, or learning, in adult subjects. It offers many advantages for work with infants; in particular, the advantage of being a specific response which can be easily elicited by appropriate stimuli and can be studied developmentally with little basic change in procedure.

The usual procedure with adults and older children is to make a mechanical attachment from the subject's eyelid to a microtorque potentiometer, which forms the external arms of a polygraph strain gauge coupler. While this instrumentation gives a satisfactorily linear recording of eyelid movements, the size of the equipment, the necessity of using a headset, and the difficulty of maintaining the proper potentiometer arm-eyelid relationship through a mechanical connection make it very difficult, if not impossible, to use with newborns and other infants. The infant will not remain in a fixed position and movements of the head may produce artifacts and change the calibration of the mechanism for recording response. Further, the subject will not tolerate or will remove pick-up devices that are not secured. The small size of the subject requires that anything attached to him be lightweight; it must also be noninjurious to the skin and able to withstand cleaning with alcohol. These difficulties do not prevent obtaining an all-or-none measure of response, but what is desired is the response form of the closing without the response form being affected by gross body movements of the infant.

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What is needed is a small sensing device, perhaps taped to, or with connections to the eyelid, which will provide signals that can be converted into a recording of the response form of the eyelid closure. The device should detect movements as small as 1 mm. (perhaps relative to a second fixed device) and follow the closure (which covers 0.25 - 0.5 inches in about 0.05 seconds).

Authority: Professor Leonard E. Ross, Department of Psychology, University of Wisconsin.

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No. UW-3

## Miniaturized Equipment for Presenting Auditory Stimuli

What is Needed: Miniaturized equipment that will permit the delivery of acoustic stimuli to the ears of infants and young children, with the same fidelity provided by high quality earphones.

Background: Earphones commercially available are too large, and uncomfortable, for use with newborns, infants, or even in some cases with young children, although many experimental problems require the presentation of precise auditory stimuli.

The usual procedure has been to position a loud speaker in proximity to the child. This involves two major disadvantages. First, the sound properties of the room become critical (in terms of standing waves, etc.) and even in sound attenuating chambers the enclosure holding the child (i.e., a glass or metal walled crib) introduces changes in the stimuli with changes in the baby's heat position, etc. A second disadvantage of speaker use is that the child must be moved out of the ward to a separate room to avoid the other children hearing the stimuli. Often equipment could be located in the ward, avoiding the transport problems in precarious medical cases, if the sound stimuli could be administered to a single infant.

Miniaturized equipment would also be advantageous in working with older children, especially those retarded, since the equipment could more easily be built into a "space helmet," which a child will tolerate as part of a game. In the case of newborns and infants restricted to cribs, the equipment would need to be small and light enough to be held with a small headband that would not be uncomfortable for the child.

Authority: Professor Leonard E. Ross, Department of Psychology, University of Wisconsin.

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No. CI-1

## Miniature Motors and Batteries

What is Needed: Miniature direct current motors and batteries for body implants. A specific application requires a battery operated motor that works on a maximum of 6 volts, provides a running torque of at least 0.75 in.-lb. at a minimum of 800 rpm, a minimum break away torque of 1.25 in.-lb. The motor diameter should be 1 in. or less, intermittent duty of 1 to 4 sec. per cycle with a minimum of 100 cycles during 10-12 hr. per day.

Background: Personnel at the Case Institute of Technology are investigating the possibility of making an implantable artificial muscle. Consideration is being given to using a d.c. motor/lead screw combination to provide the required linear motion. Miniature batteries and d.c. motors with high torques per volume are required for this application.

Source of Problem: Dr. James B. Reswick, Engineering Design Center, Case Institute of Technology, Cleveland, Ohio.

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No. CI-2

## Joint Lock for Orthosis

What is Needed: An electrical positioning lock which would allow the joint on an orthosis to be easily and accurately positioned at any desired angle, without "hunting." The unit should be no larger than 2 in. diameter x 3/4 in. long, have a torque capacity of at least 5 ft.-lb., and operate on a minimum of 30 volts.

Background: An orthosis is an exoskeletal structure which assists a paralyzed limb. These devices are sometimes called braces or splints and usually constrain the movement of the skeletal joints. If it is desired to move the skeletal joint, a ratchet-type lock has been incorporated into some orthoses to hold the joint immobile at discrete angles. The lock is usually actuated by running a cable to a normally functioning part of the body. The main disadvantages of these joint locks are the limited number of locking positions (increments of about 10 degrees) and the hunting required to locate the lock position. Commercial electromagnetic clutches and brakes are too bulky and heavy.

Source of Problem: Dr. James B. Reswick, Engineering Design Center, Case Institute of Technology, Cleveland, Ohio.

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# APPENDIX II

## INDUCED POSTURAL REFLEX REACTIONS AS RELATED TO THE DIAGNOSIS OF CEREBELLAR AND LABYRINTHINE LESIONS

# INDUCED POSTURAL REFLEX REACTIONS AS RELATED TO THE DIAGNOSIS OF CEREBELLAR AND LABYRINTHINE LESIONS

By Sister M. Agnita Claire Day, S.S.M., R.N., M.S.,
Department of Nursing and Physiology,
Saint Louis University

The postural reflexes under study are those which enable the body to maintain balance and equilibrium. The reflex mechanisms governing the orientation of the head in space, the position of the head in relation to the trunk, and the appropriate adjustment of the limbs and eyes to the position of the head are called into action by afferent impulses discharged from receptors located in the (1) vestibular apparatus, (2) joint surfaces of the upper cervical vertebrea and the lumbar vertebrae, (3) retina, (4) body wall and limb muscles, (5) cutaneous touch receptors, and no doubt, others currently unknown.

The patterns of the tonic neck and labyrinth reactions have been worked out fairly completely on decerebrate animals (cats, dogs, rabbits, etc.). Comparable reactions have also been reported in human adults suffering from some form of partial or complete decerebration as the result of disease or injury, and in normal infants and foetuses. These reactions, however, are not so easily identifiable in the normal adult in whom the higher cortical centers are intact, because of the overlay of voluntary movement. Since no so-called "voluntary movement" is purely voluntary, however, but is largely carried out by means of postural reflex reactions once the movement has been voluntarily initiated, it is possible to detect the influence of these reflexes by intensive observation. Fukuda, who studied the dynamic posture of athletes, has identified many of them. Although he noticed certain discrepancies which occurred with changes in the position of the head, he made no attempt to explain them at the time, but felt they were due to unknown factors, not yet recognized. We now know that most of those he mentioned were due to minute variations in the position of the head not easily noticeable without intensive study and experimentation.

Hellebrandt has written one of the most comprehensive reviews in recent literature on methods of producing tonic neck and labyrinthine reflexes in the normal subject and has confirmed work done by many of the early researchers in this field. We have been able to reproduce her experiments with similar results in most cases, and have also studied reactions she does not include in her review.

During the course of our experimentation it has been possible to demonstrate many of the statotonic and statokinetic reflexes using involuntary movements of the extended arms as the indicators of changes in muscle tone

produced by movements of the head, eyes, limbs, trunk, etc. The control position adopted for many of our experiments (and the one used in the present study) is that used by Hoff and Schilder in 1927, namely the erect standing position with feet close together to form as narrow a base of support as possible, the eyes closed to eliminate visual reflexes, and the arms raised horizontally forward to form a 90° angle with the trunk; wrists and fingers are loosely extended. The trunk is voluntarily held in the upright position. This position eliminates the lumbar and body righting reflexes which occur when the trunk is permitted to relax to "follow the head" as it almost invariably does if there is no resistance to the reflex movements. These movements of the trunk, in turn, stimulate many other complex reactions which are also stereotyped in nature, but are much more difficult to interpret.

The reactions which occur with the control position described above have been produced in many experimental subjects and the "normal" reaction might be described as follows: after a few seconds of latency both arms begin to diverge and swing outward in horizontal abduction (slowly or rapidly depending upon the degree of inhibition of voluntary control the subject is able to maintain). In the trained subject who has learned to "shut off" all voluntary control of the movements, the arms usually go through an 80° to 90° arc until extended laterally at the shoulders. The resulting tension placed upon the horizontal adductors causes them to contract and the arms once more converge to the starting position. The movements are repeated as long as one can maintain this position, with each cycle becoming a little more rapid than the previous one until a point is reached where the oscillations of the arms become stabilized at an almost steady rate. As one becomes fatigued the movements eventually become still faster. These movements can probably be explained as the result of reflex contraction caused by stretching of the muscles involved. Neck and labyrinth reflex patterns can be demonstrated by changing the position of the head systematically -- all other factors remaining the same -- and noting the effect of these positions on the reflex movements of the arms.

Before the MRI muscle accelerometers were available the postural reactions were studied intensively by means of direct observation and cinematography. While attempts were made, at the time, to time the movements with a stop watch, such timing was not accurate. Counting frames of movie film was not much better because of the difficulty of recognizing the exact frames in which the movements began and ended.

Using the MRI muscle accelerometers, mounted on the middle finger of each hand, with a Sanborn two or four channel recorder, it has been possible to time each movement accurately on the recorded graph and to plot an individual's "mean time curve" over a period of several months, not only for the control reaction but for those caused by changing the position of the head.

In order to determine the possible diagnostic value of induced postural reflex patterns, especially in differentiating between labyrinthine and cerebellar pathology, a preliminary series of 25 patients with labyrinthine and cerebellar syndromes have been studied: 5 by direct observation only, 15 by cinematography which makes multiple observations possible, and 5 by study of patterns of movement as recorded by means of the MRI muscle accelerometers and Sanborn recorder, as mentioned above. While work with these accelerometers are just beginning they show promise of providing much additional data and hopefully characteristic patterns of response, although it is too soon to be certain.

The primary diagnosis of the patients involved varied considerably. The first 20 patients fell into two main groups, however; 10 (3M, 7F) who were thought to have labyrinthine involvement and 10 (3M, 7F) who showed cerebellar symptoms. Of the 10 with labyrinthine involvement, 4 were superimposed on other neurological pathology. Of the 10 who showed cerebellar symptoms, 3 had additional brain stem involvement and 3 were superimposed on cerebral complications. All patients were subjected to certain standard neurological tests as well as to postural reflex tests. The results are outlined in Table I.

The 5 patients checked with the MRI accelerometers fitted into previously observed brain stem and cerebellar patterns, but the additional data of a permanent graph gave more objective information. For the first 3 patients the accelerometers used did not have the same sensitivity. These records, therefore, are inconclusive, but do show a number of possibilities. For the last 2 patients new accelerometers of equal sensitivity were calibrated to give records of equal amplitude. These records are more accurate and demonstrate not only tremor rates and amplitudes, but make it possible to compare the tracings of both arms for similarities and differences. Changes in head position changed the amplitude of the tremors but not the rate in the patients observed, and the influence of head positions on the sway patterns can also be detected. With further study and practice in reading the records they should become more meaningful.

Conclusions: The results to date, as herein tabulated, do not give a picture of clear cut differences between the signs and symptoms of labyrinthine and cerebellar involvement on the postural reflex tests alone. It has been noted, however, that these tests do exaggerate symptoms sufficiently that differences do stand out on the standard neurological tests. It is also apparent that any pathology which may be present is brought out by these positions; therefore, they can be used as a screening device. Certain positions of the head lessen body sway and tremors; these might be very helpful as a tool for rehabilitation. Further use of the MRI accelerometers may furnish additional objective data which cannot now be detected by direct observation alone.

TABLE I

TABULATED DATA ON 20 PATIENTS

| Tests | 10 Patients With Symptoms of Labyrinthine Involvement | 10 Patients With Symptoms of Cerebellar Involvement |
|---|---|---|
| GAIT | Tended to be very unsteady. A few showed tendency to fall. Righting reflexes weak. 5 showed unilateral deficits, 3 bilateral; 2 demonstrated no labyrinthine symptoms. | Usually ataxic but showed little tendency to fall. Righting reflexes seemed strong. 7 had wide-based ataxic gait; 2 showed uncertain gait but less ataxia; 1 not checked. |
| TREMORS | No gross tremors except in 4 patients with additional neurological conditions. | Tremors predominated: 7 had gross tremors of arm and/or leg; were not apparent in 3. |
| NYSTAGMUS | 5 showed nystagmus with the eyes turned toward the side opposite to that to which they lost balance. 5 showed no nystagmus. | 3 showed nystagmus with the eyes turned toward the side to which they swayed; 1 both lateral and vertical; 1 vertical only; 2 no nystagmus. |
| COORDINATION TESTS | In general there was little difficulty with coordination tests unless there were additional basic neurological conditions. | Showed difficulty with coordination tests. Arrythmia, slowing of movements and dissociation of movement occurred. |
| VISION AND CRANIAL NERVE INVOLVEMENT | 4 reported some problem with vision in addition to vertigo, such as diplopia; 1 needed his glasses changed; 5 had vertigo only; 1 had other cranial nerve involvement. | 3 reported double vision without nystagmus; 2 had signs of other cranial nerve involvement; 5 showed no such involvement. |
| POSTURAL REFLEX CONTROL POSITION | Swaying and falling tendencies were exaggerated in all but one. In only one case was inward rotation of the hands present. Any tremors were exaggerated. | Swaying was exaggerated but few showed any tendency to fall. All tended to be somewhat rigid in stance. 7 showed inward rotation of hand on side of lesion. Tremors exaggerated. |
| HORIZONTAL ROTATION OF HEAD TO RIGHT OR LEFT | Stability was increased on rotation of head to side opposite the original direction of sway or fall. Stability was decreased on rotation of the head to the other side. In the 3 bilateral cases swaying increased to side toward which head was turned. Slight deviations from horizontal reversed reactions. | The same reactions occurred as described for labyrinthine defects. Tremor amplitudes seemed increased when head was rotated horizontally toward side of tremor and decreased when head was turned to the other side. (Accurate visualization of this reaction is difficult without instrumentation.) |
| VENTROFLEXION OF HEAD | Stability increased in 8 out of 10 patients. In 2 it made little difference. | Stability increased in 8 out of 10 patients. In 2 it did not. |
| DORSIFELXION OF HEAD | Swaying and falling tendencies were increased in 7. In 3 there was little effect. | Swaying tendencies were increased in 6; 2 were more stable; 1 fell backward when eyes were open; 1 was not attempted. |

# APPENDIX III

## NASA TECH BRIEFS

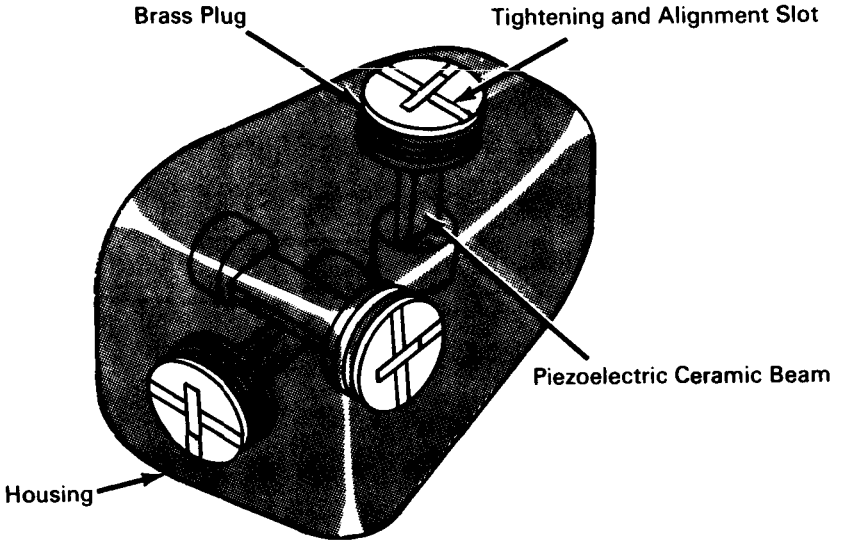
November 1966

Brief 66-10534

# NASA TECH BRIEF



## Miniature Piezoelectric Triaxial Accelerometer Measures Cranial Accelerations




**The problem:**

To design and build a triaxial accelerometer to measure human cranial accelerations when a subject is exposed to a centrifuge or other simulators of g environments. The size and shape must be suitable for attachment to the teeth without discomfort.

**The solution:**

A tiny triaxial accelerometer whose sensing elements are piezoelectric ceramic beams. The accelerometer physical shape is compatible to a human mouth and may be attached to the teeth by an appropriate bridge and located behind the upper teeth in the roof of the mouth. The sensitivity is about 20 millivolts (rms) per g and the frequency response is essentially flat over the range tested (5 to 500 cps).

**How it's done:**

The accelerometer consists of three orthogonal cantilever beams of piezoelectric ceramic material mounted in an aluminum case having external dimensions approximating those of a human molar. The beams are 0.2-inch in length and each has a gold weight bonded to the free end. The beams are located in a slot cut in a brass threaded plug and bonded in place with a nonconductive epoxy cement.

All three elements are made identical as far as possible. A slot on the brass plug face provides an alignment reference. Insulated soft copper wires are soldered to the top and bottom electrodes of each beam and passed through the open slot of the plug along the beam side. The elements are then inserted

(continued overleaf)

into the housing and potted in place with epoxy cement.

**Notes:**

1. In testing, the linearity for all components proved to be excellent. Sensitivity was of the order of 20 millivolts (rms)/g. The repeatability was excellent and the response was essentially flat over the entire range tested (5 to 500 cps). The cross axis sensitivity did not exceed 5.5 percent.
2. A related innovation is described in NASA Tech Brief B64-10004, "Ultrasensitive Transducer Advances Micromeasurement Range," May 1964. A method of testing piezoelectric transducers is described in NASA Tech Brief B66-10533,"Method Permits Mechanical and Electrical Checkout of Piezoelectric Transducers While Installed in a System," November 1966.
3. This device could be considered for application in dental, medical, and automotive safety research.
4. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Ames Research Center
   Moffett Field, California 94035
   Reference: B66-10534

**Patent status:**

No patent action is contemplated by NASA.

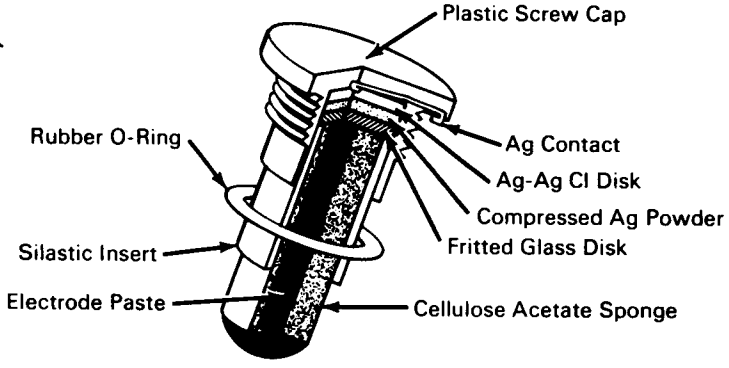
Source: V. L. Rogallo and G. J. Deboo (ARC-71)

November 1966 Brief 66-10536

# NASA TECH BRIEF



## Helmet System Broadcasts Electroencephalograms of Wearer




**The problem:**

To develop an improved system for obtaining electroencephalograms (EEG's) of pilots and astronauts performing tasks under stress. In the past, electrodes were cemented to the scalp and were uncomfortable, irritated the scalp, and took as long as an hour to attach. Furthermore, the wires to the readout equipment restricted the subject's motions.

**The solution:**

An EEG monitoring system consisting of non-irritating sponge-type electrodes, amplifiers, and a battery-powered wireless transmitter, all mounted in the subject's helmet. No preparation of the scalp is required. After a quick initial fitting, the helmet can be removed and replaced without further adjustment. There are no external wires.

**How it's done:**

A flight helmet is modified to contain the EEG electrodes and the electronic components. The elements of the system fit conveniently in the helmet and do not impair its usefulness as a protective device.

The key element in this system is the EEG electrode, which consists of a flexible portion that rests against the scalp and a rigid portion that fits securely in the helmet and is connected to the amplifier. The flexible portion consists of a hollow-core cellulose acetate sponge impregnated with an electrode paste. The rigid portion consists of the following: a disk of fritted glass wetted with a saline solution; a disk of compressed silver powder; a disk of Ag–AgCl; and a solid silver contact which connects with the amplifier.

Fitted to the subject, the sponge portion containing the electrode paste contacts the scalp with a light

(continued overleaf)

steady pressure. This member can accommodate a certain amount of relative motion between the scalp and the helmet without altering the electrical properties of the connection or distorting the signal.

The remaining elements of the system are a pair of miniature biomedical amplifiers, a pair of commercially available FM subcarrier oscillators, a miniature PM transmitter operating at 108 MHz, and standard miniature mercury cells that provide 90 hours of continuous operation.

**Notes:**

1. The helmet shell comes in three basic sizes, and by selection of liner size and length of replaceable sponge, the helmet can be adapted to any subject. Initial fitting requires only about five minutes.
2. Experiments with a variety of subjects (some with thick hair, with and without hairoil, and some bald) have been made in the laboratory, in flights of a T-33 airplane, and in centrifuge runs. The data obtained have been consistent with EEG records obtained with carefully applied metallic electrodes.
3. A related innovation is described in NASA Tech Brief B65-10203, July 1965.
4. Inquiries may also be directed to:

   Technology Utilization Officer
   Ames Research Center
   Moffett Field, California 94035
   Reference: B66-10536

**Patent status:**

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: Richard M. Westbrook and Joseph J. Zuccaro
(ARC-70)

July 1965

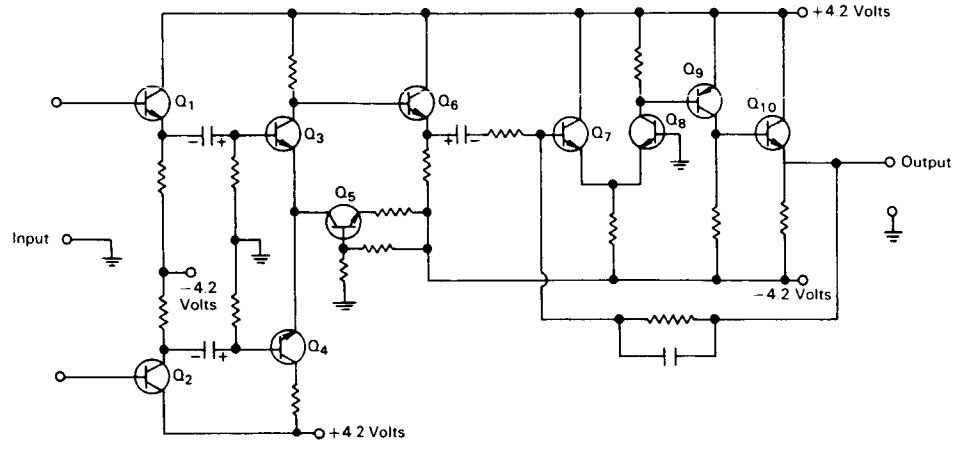
ASTRA

Brief 65-10203

# NASA TECH BRIEF



## Tiny Biomedical Amplifier Combines High Performance, Low Power Drain




**The problem:** To facilitate biomedical studies on mobile subjects, develop a miniaturized, high-performance, high-reliability, battery-operated, solid-state amplifier of low power consumption, that is suitable for both general biomedical use and space research. Amplifiers meeting the requirements of physiological research are available commercially, but they are often too bulky and require too much power for many applications. Small amplifiers have been developed but often with compromise of some aspect of performance.

**The solution:** A transistorized, portable, high-performance amplifier that utilizes a differential input to obtain a common-mode rejection of 25,000 to 1. Because of its small size and low power drain it may be mounted directly on an ambulatory subject.

**How it's done:** Transistors $Q_1$ and $Q_2$ are emitter followers and provide the necessary high input impedance of about 10 megohms differential. The differential output of the emitter followers is converted to a single-ended signal by a difference amplifier consisting of $Q_3$, $Q_4$, and $Q_5$. Transistor $Q_5$ provides the difference amplifier with the high emitter impedance necessary for high common-mode rejection. The signal is fed sequentially through an emitter follower $Q_6$, a second difference amplifier $Q_7$ and $Q_8$, a common emitter amplifier $Q_9$, and a final emitter follower $Q_{10}$. Capacitance coupling in these stages is minimized to provide good low frequency response from 0.15 cps. The amplifier exhibits a gain of 1,000 while drawing 5 milliwatts of power.

**Notes:**

1. This amplifier has been constructed in a weld-connected cordwood configuration with dimensions of 2.0 cm by 1.7 cm by 0.9 cm and weighing 4.5 grams.
2. This device should find application in the biomedical field for amplifying electrocardiogram and electromyogram signals.

(continued overleaf)

3. Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Ames Research Center
Moffett Field, California, 94035
Reference: B65-10203

**Patent status:** NASA encourages commercial use of this innovation. No patent action is contemplated.

Source: Thomas B. Fryer and
Gordon J. Deboo
(ARC-41)

APPENDIX IV

MEDICAL PROBLEM LIST

## MEDICAL APPLICATION OF NASA-DEVELOPED SCIENCE AND TECHNOLOGY
## MEDICAL PROBLEM STATUS

CONTRACT NO. NASr-63(11) MRI PROJECT NO. 2961-E

| PROBLEM NUMBER | PROBLEM DESCRIPTION | PREPARED DIGEST | INITIATED LITERATURE SEARCH | NASA ITEM IDENTIFIED | NO NASA ITEM IDENTIFIED | ADAPTATION COMPLETED | EVALUATION POSITIVE | EVALUATION NEGATIVE | INFORMATION DISSEMINATED |
|---|---|---|---|---|---|---|---|---|---|
| | University of Kansas Medical Center | | | | | | | | |
| KU-1* | EKG electrodes that will function adequately during vigorous exercise, such as riding a bicycle ergometer or running on a track. | X | X | X | | X | X | | X |
| KU-2* | A method of continuously measuring respiratory oxygen consumption and $CO_2$ production during exercise. Continuous computation of the ratio of ($CO_2$ produced)/($O_2$ consumed) is also desirable. | X | X | X | | | | | |
| KU-3* | A method for making direct intravascular measurements of pH, $P_{O2}$, and $P_{CO2}$ during exercise. A technique for making such measurements over a period of a few days is also needed. | X | X | X | | | | X | |
| KU-4 | Reasonable priced apparatus for telemetering EKG's and other physiological data. | X | X | X | | | | X | |
| KU-5* | Masks and/or mouthpieces that have low resistance to air flow, so as to minimize the extra work imposed by respiratory monitoring during exercise. | X | X | X | | X | X | | X |

* Pursued during the period 1 April 1966 - 1 April 1967

## MEDICAL APPLICATION OF NASA-DEVELOPED SCIENCE AND TECHNOLOGY
## MEDICAL PROBLEM STATUS

CONTRACT NO. NASr-63(11)

MRI PROJECT NO. 2961-E

| PROBLEM NUMBER | PROBLEM DESCRIPTION | PREPARED DIGEST | INITIATED LITERATURE SEARCH | NASA ITEM IDENTIFIED | NO NASA ITEM IDENTIFIED | ADAPTATION COMPLETED | EVALUATION POSITIVE | EVALUATION NEGATIVE | INFORMATION DISSEMINATED |
|---|---|---|---|---|---|---|---|---|---|
| KU-6* | A technique for rapid measurement of lactic and pyruvic acids in tissues and blood. | X | X | X | | | | X | |
| KU-7* | Improvements in the protective clothing used in athletics, especially high school athletics. | X | X | X | | | | | |
| KU-8* | A device for nondestructive testing of the integrity and/or density of bone in vivo. | X | X | X | | | | | |
| KU-9* | Powered prosthetic devices and control systems that allow paralytics amputees to gain function and mobility. | X | X | | X | | | | |
| KU-10* | Microsurgical instruments, such as a microdrill and microforceps, that can be used for middle and inner ear surgery. | X | X | | X | | | | |
| KU-11* | Miniature transducers that can be used to measure the compliance of the acoustic transmission system in the middle ear. | X | X | | X | | | | |

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|---|---|---|---|---|---|---|---|---|---|
| KU-12 | A larynogostroboscope that can be used to observe the dynamic behavior of the vocal cords. It should be possible to synchronize the strobe frequency with the generated sound. | | X | X | | | | X | |
| KU-13* | A miniature sensor which can be placed in the nasal cavity to monitor the pH of nasal mucosa secretion. | | X | X | | | | X | |
| KU-14* | A frequency converter for transposing frequencies from the lower audible range (say 200 cycles to 4 kc.) into a higher range (for example, 4 kc. to 8 kc.) that would make it possible to recover "hearing" in some cases of nerve deafness. | X | X | X | | | | | |
| KU-15* | A nasal pack that can be used to arrest bleeding. | X | X | X | | | | X | |
| KU-16* | Miniature accelerometers that can be used to detect muscle movements during neurosurgery. | X | X | X | | X | | | |
| KU-17* | A device for producing lesions of well-defined shape and size in neurosurgery. | X | X | X | | | | | |

# MEDICAL APPLICATION OF NASA-DEVELOPED SCIENCE AND TECHNOLOGY
## MEDICAL PROBLEM STATUS

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| PROBLEM NUMBER | PROBLEM DESCRIPTION | PREPARED DIGEST | INITIATED LITERATURE SEARCH | NASA ITEM IDENTIFIED | NO NASA ITEM IDENTIFIED | ADAPTATION COMPLETED | EVALUATION POSITIVE | EVALUATION NEGATIVE | INFORMATION DISSEMINATED |
|---|---|---|---|---|---|---|---|---|---|
| KU-18* | An endoradiosonde method for measuring the pH of colonic contents. | X | X | | X | | | | |
| KU-19 | A micro-assay technique for ATP. | | | | | | | | |
| KU-20* | A technique for separation of the fetal EKG from the maternal EKG and from noise. | X | X | X | | | | | |
| KU-21* | An intrauterine camera, perhaps employing fiber optics. | X | X | X | | | | | |
| KU-22 | Techniques for determination of biological steroids by gas chromatography. | | | | | | | | |
| KU-23* | Support to assist healing of eardrum rupture. | X | | | | | | | |
| KU-24* | Cardiac output measurements. | X | | X | | | | | |

## MEDICAL APPLICATION OF NASA-DEVELOPED SCIENCE AND TECHNOLOGY
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| PROBLEM NUMBER | PROBLEM DESCRIPTION | PREPARED DIGEST | INITIATED LITERATURE SEARCH | NASA ITEM IDENTIFIED | NO NASA ITEM IDENTIFIED | ADAPTATION COMPLETED | EVALUATION POSITIVE | EVALUATION NEGATIVE | INFORMATION DISSEMINATED |
|---|---|---|---|---|---|---|---|---|---|
| | St. Louis University School of Medicine | | | | | | | | |
| SLU-1 | Signal generator for use in electrical anesthesia. | | X | | X | | | | |
| SLU-2* | Infrared photography and thermography. | | X | X | | | | | |
| SLU-3* | Color film X-rays. | | X | | X | | | | |
| SLU-4* | Electrocardiographic electrodes. (This problem is identical with No. KU-1.) | X | X | X | | X | | | |
| SLU-5* | Sensors for pH and motility in stomach and gut. | | X | | X | | | | |
| SLU-6 | Automatic 24-hr. monitoring of blood pressure. | | | X | | | | | |
| SLU-7* | Measurement of muscle tremor rates. (This problem is closely related to No. KU-16.) | | X | X | | X | X | | X |
| SLU-8* | Measurement of blood oxygen by ear-lobe or skin sensors. | | | | | | | | |
| SLU-9 | Telemetry of physiological data. (This problem is identical with No. KU-4.) | X | X | X | | | | X | |

## MEDICAL APPLICATION OF NASA-DEVELOPED SCIENCE AND TECHNOLOGY
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|---|---|---|---|---|---|---|---|---|---|
| SLU-10* | Fiber-optic telescope for examining the respiratory tract. (This problem is related to No. KU-21.) | | X | X | | | | | |
| SLU-11 | Miniaturization of instrument for hearing tests. | | | | | | | | |
| SLU-12 | Portable urinalysis kit. | | | | | | | | |
| SLU-13 | Assay of bone calcium without biopsy. | | X | X | | | | | |
| SLU-14 | A means for measuring the pressures inside the semicircular canals without damaging the canals. | | | | | | | | |
| SLU-15 | A technique for measuring the electrical potential on the eighth cranial nerve branch. | | | | | | | | |
| SLU-16* | Improved techniques for measuring the total blood flow rate to the brain. | | X | X | | | | | |
| SLU-17 | A method for measuring the blood flow in the various regions of the brain. | | | | | | | | |

## MEDICAL APPLICATION OF NASA-DEVELOPED SCIENCE AND TECHNOLOGY
## MEDICAL PROBLEM STATUS

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|---|---|---|---|---|---|---|---|---|---|
| SLU-18 | Improved techniques for measuring the sensitivity of the brain to changes in blood supply. | | | | | | | | |
| SLU-19* | Smaller electrodes to measure pH, $P_{CO_2}$ and $P_{O_2}$ in the brain blood vessels. | | X | | X | | | | |
| SLU-20 | Techniques to determine the elasticity of the blood vessel walls in the brain. | | | | | | | | |
| SLU-21 | Better radio-opaque substances for capillary visulization in the brain. | | | | | | | | |
| SLU-22* | Automatic analysis of electromyograms. | X | X | | X | | | | |
| SLU-23* | Miniaturized artificial kidney. | X | X | | X | | | | |

# MEDICAL APPLICATION OF NASA-DEVELOPED SCIENCE AND TECHNOLOGY
## MEDICAL PROBLEM STATUS

CONTRACT NO. NASr-63(11) MRI PROJECT NO. 2961-E

| PROBLEM NUMBER | PROBLEM DESCRIPTION | PREPARED DIGEST | INITIATED LITERATURE SEARCH | NASA ITEM IDENTIFIED | NO NASA ITEM IDENTIFIED | ADAPTATION COMPLETED | EVALUATION POSITIVE | EVALUATION NEGATIVE | INFORMATION DISSEMINATED |
|---|---|---|---|---|---|---|---|---|---|
| | University of Minnesota Medical School | | | | | | | | |
| UM-1* | Sterile atmosphere for surgical and postsurgical procedures. | X | X | X | | | | | |
| UM-2* | A pump for an artificial implantable heart. | X | X | X | | | | | |
| UM-3* | A device to store electrical energy with the lowest weight per unit of stored electrical energy that is possible. | X | X | X | | | | | |
| UM-4* | A rapid scanning frequency spectrum analyzer for the audio range of frequencies. | X | X | X | | | | | |
| UM-5 | Multichannel telemetry systems for biomedical applications. The unit should be small and lightweight. | | X | X | | | | | |
| UM-6* | An improved instrument to measure respiratory air flow rates. | X | X | X | | | | | |
| UM-7* | A method for measuring the flow of blood in bones. | X | X | | X | | | | |

# MEDICAL APPLICATION OF NASA-DEVELOPED SCIENCE AND TECHNOLOGY
## MEDICAL PROBLEM STATUS

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|---|---|---|---|---|---|---|---|---|---|
| UM-8* | A method to measure bone distortion. | X | X | X | | | | | |
| UM-9* | New approaches to the indirect measurement of arterial blood pressure. | X | X | X | | | | | |
| UM-10 | Microcirculation measurement. | | | | | | | | |
| UM-11 | Muscle heat measurement. | | | | | | | | |

## MEDICAL APPLICATION OF NASA-DEVELOPED SCIENCE AND TECHNOLOGY
## MEDICAL PROBLEM STATUS

CONTRACT NO. NASr-63(11) MRI PROJECT NO. 2961-E

| PROBLEM NUMBER | PROBLEM DESCRIPTION | PREPARED DIGEST | INITIATED LITERATURE SEARCH | NASA ITEM IDENTIFIED | NO NASA ITEM IDENTIFIED | ADAPTATION COMPLETED | EVALUATION POSITIVE | EVALUATION NEGATIVE | INFORMATION DISSEMINATED |
|---|---|---|---|---|---|---|---|---|---|
| | Northwestern University Medical School | | | | | | | | |
| NU-1* | Measurement of Temporomandibular Joint Action | X | | X | | | | | |
| NU-2* | Telemetry System for Football Players | X | | X | | | | | |
| | Case Institute of Technology | | | | | | | | |
| CI-1* | Miniature d.c. motors and batteries | X | X | X | | | | | |
| CI-2* | Joint locks for orthosis | X | X | X | | | | | |
| CI-3* | Packaging materials for implanted electronics | X | X | X | | | | | |
| CI-4* | Radio-frequency telemetry link | | X | X | | | | | |
| CI-5* | Micropower circuitry | | X | X | | | | | |

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|---|---|---|---|---|---|---|---|---|---|
| | University of Wisconsin Medical School | | | | | | | | |
| UW-1* | Delivery of Water and Medication to the Respiratory Tract | X | X | X | | | | | |
| UW-2* | Eyelid Closure Recording | X | X | X | | | | | |
| UW-3* | Miniature Equipment for Presenting Auditory Stimuli | X | X | X | | | | | |

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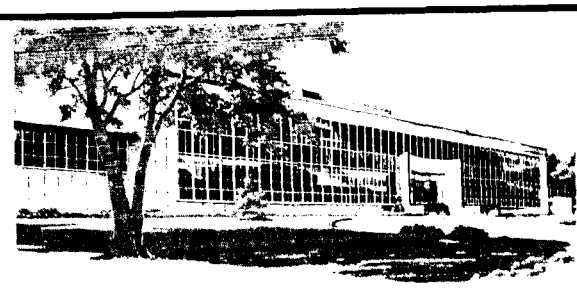

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